Dynamic Acousto-Elasticity in a closed, fatigue-cracked sample

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Dynamic Acousto-Elasticity (DAE) provides a unique way to observe nonlinear elastic features over an entire dynamic stress cycle including hysteresis and memory effects, detailing the full nonlinear behavior under tension and compression. This supplemental information cannot be observed with conventional nonlinear ultrasonic methods such as wave frequency mixing or resonance measurements, since they measure average, bulk variations of modulus and attenuation versus strain level. Where prior studies have employed DAE in volumetrically nonlinear materials (e.g., rocks, bone with distributed micro-crack networks), here we report results of DAE on the application to a single localized nonlinear feature, a fatigue crack, to characterize the nonlinear elastic response in regions of the crack length, tip, and undamaged portions of an aluminum sample. Linear wave speed, linear attenuation and nonlinear parameters each indicate a sensitivity to the presence of the crack, though in unique manners. The localized nature of the DAE measurement and its potential for quantifying all of the third order elastic constants makes it a promising technique for both detecting cracks, as well as providing quantitative information on the effect of the cracks on the material integrity.